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VOL. XIX NOVEMBER No. 7

THE TEACHING OF ASTRONOMY IN OUR SCHOOLS*

By ERNEST A. HODGSON

THE subject of the lecture this evening is an important one. It should be given to a larger audience than can be reached here tonight, and by some one better qualified to stress the facts in a manner that might bring conviction and secure practical application of them. It is a subject which has interested me, off and on, for the past fifteen years, throughout an experience which has been varied, touching not only on the subject of astronomy, but on the way in which it is taught to students of all ages.

Since the material to be presented grows out of my own experiences, the personal pronoun, for purposes of convenience, must frequently appear. May I beg of you the indulgence to believe that this does not mean that the opinions are dogmatically expressed; it does not imply that I do not recognize that most of my suggestions are impracticable under some circumstances, though I do not believe that any situation would be found in which many of them could not be used. You are not to think that the problems of overcrowded curriculums are not constantly in mind. In endeavouring to make sure of the proper plural—curricula or curriculums—the word was looked up in the dictionary. The plural, by the way, was given as curriculums. The first meaning given impressed me however. Webster says, first of all, that curriculum means—*a race-course*. That seems to me a very appropriate definition. The first inclination of every teacher is to

*Delivered before the Ottawa Centre of the R.A.S.C., November 12, 1925.

resent the introduction of an added factor into the ever present and ever pressing necessity of equating the curriculum to the school year. The lecture will simply lay before you as large an assortment of tested methods, which proved successful under certain conditions, as time will permit. You are as welcome to them as you would be to the time-tables in a ticket office. Make a selection of some, or all, or none, as best suits your needs.

The plan which will be followed in the lecture may well be outlined at this point; it will serve to hold together a series of, what would otherwise be, unconnected items. I shall begin by giving five of the many reasons why astronomy should be studied because of the information it is able to give. Next I shall endeavour to find a place for astronomy in our, already crowded, curriculum. Following this, the greater part of the lecture time will be devoted to an outline of what is meant by a course in observational or laboratory astronomy which may be undertaken by the schools. After thus defining what is meant by this method of teaching, the relation of astronomy to many of the subjects of the school course is to be indicated. This brings us to the problem of the difficulties involved in an attempt to incorporate observational astronomy as part of each of the subjects taught. It is only possible to attack this problem in a most general way in this lecture, but concrete examples would yield to the adaptations of this general method. In conclusion I shall touch on the wonderful possibilities of observational astronomy as regards the cultural results.

A few of the evident, immediate reasons why astronomy should be taught in our schools may be briefly listed as follows:

1. Time is an essential part of our everyday life. Travel, radio programmes, press dispatches—all emphasize the need of an undertanding of what time is and how it is reckoned. How many people, well educated in other respects, know just how time is obtained through astronomical observations—upon which it depends? How many hesitate when it comes to setting the clock for Daylight Saving? When it is midnight at Ottawa tonight it is November 13th from Greenwich to Ottawa, and November 12th to the west of Ottawa. What date is it at that instant at Tokyo? At what other position do the two dates meet? Astronomy,

taught in our schools, should make all such questions readily understood by everyone.

2. Intelligent people should know by experience the simple astronomical facts which can be learned by observations without instruments. One never knows when they may be required. Some years ago I was lost when on a long ride alone on the western prairies. I knew only the stars of the Big Dipper and Polaris. The fact that they rotated about Polaris had not occurred to me, nor had I observed the Dipper in any but the orthodox upright position, capable of holding water. I could not find them in the partially clouded sky when darkness overtook me at least ten miles from anywhere I knew. The moon was visible—low in the west as I supposed. It was so far down I thought it was setting. I didn't know that, as it was nearly full, it could not be setting so early. Neither did I know that the latitude, higher than I was used to, accounted for its low elevation. Concluding that it was in the west I shaped my course accordingly. There were no fences. The road was visible for only a few feet ahead. The result was that I was at last forced to tether the horse for the night and fight off the mosquitoes as best I could until the gathering dawn revealed the metal roof of a grain elevator, miles away. Anyone is liable to be placed in a position somewhat the same in these days of motor touring and hunting expeditions. A compass is not always at hand. A knowledge of elementary astronomy is of value in such cases for giving approximate time or direction.

3. Literature of all kinds has many references to astronomy. Our Bible is full of it. Joseph dreamed a dream and behold the sun and moon and eleven stars made obeisance unto him. The eleven stars refer to the, then, eleven divisions of the zodiac into constellations. What are the months referred to in different parts of the Bible? What are the "chambers of the south"? Where are the references to Orion, the Pleiades, Mazzaroth, and Arcturus? What are the references to the calendar and the difficulties of its calculation? The study of the astronomical references in the Bible alone is one which requires what our mathematics professor used to refer to as a "necessary and sufficient condition"—a good groundwork of elementary observational and

traditional astronomy. A book which should prove of interest in this connection is called *The Astronomy of the Bible.* It was written by E. Walter Maunder of Greenwich Observatory, and is published by T. Sealey Clark and Co. of London.

I have spent so much time speaking of the astronomical literature of the Bible that none remains for referring to the writings of Tennyson, Longfellow or Milton. I refrain from the usual jibe at Coleridge and pick an example of faulty astronomical knowledge from the artists. He must surely be a fireside observer that pictures a rising moon of sufficient dimensions, for example, to completely silhouette a couple, however loving, within the confines of its shining disc.

If you are not an observer of some experience try the experiment of holding a card at arm's length and tearing off bits until a strip remains just wide enough to eclipse the rising moon when held perpendicular to the line of sight and at the given distance. Then hold your strip as before, but this time between your eye and the zenith. The effect is rather unexpected. You will find, for example, that the moon could be enclosed in the small triangle of stars that marks the head of Orion.

4. This brings up another very important direct reason for teaching observational astronomy in our schools. Some years ago a very remarkable stream of meteors passed over a wide area of Ontario and parts of north-eastern United States. Questionnaires were sent out asking that descriptions should be sent in to Dr. Chant of the University of Toronto. Hundreds replied, from every walk of life. The designation of size was a hard one to answer for many. The tendency was to express it in some such terms as; two feet long; the length of the barn; or some other impossible or incomplete statement. Observational astronomy would develop the ability to observe and report celestial phenomena in such a way that the data would be of scientific value.

5. Observations, properly made, would give an appreciation of the methods used in preparing such books as the American Ephemeris. The actual book should reach the hands of high school students; not that they should study it to any great extent; but they should know where to go for astronomical information when

the need arises. Most of us would be helpless were our beneficent patent medicine companies to shut off the supply of almanacs.

The above, and other direct benefits might be obtained by the amount of astronomy already on our curriculum, taught as it is usually taught, as a collection of facts, without any experiments or observations, except perhaps the use of a helioterra, planetarium, planisphere or some such mechanical device. (These have their place but they should never precede, much less take the place of, direct observation on the heavens.) There are other indirect and more important benefits to be derived from a proper study of the subject. I shall deal with them finally. Before doing so I am confronted with the problem of finding a place for the subject on our already crowded curriculum.

Some weeks ago I found it necessary to compute the amount of broken stone, sand and cement required to make up enough concrete to fill a given volume in the wall. I found that if you add the volume of broken stone to the volume of sand, you have the volume of concrete. The cement did not add to the volume, but it did contribute to the strength of the finished job.

I propose to find a place for astronomy, properly taught, in the same way. Your school year is the volume of wall within which you are to find place for your many and varied parts of subjects, making up your present curriculum and represented by the broken stone and sand. How can observational astronomy be added so that the *forms* shall not be taxed beyond capacity? My experience with the mechanical problem of the concrete leads me to say that it is a hard job, but well worth doing.

There are so many different conditions that I can speak, for the moment, only in generalities. Let us consider for the moment the simplest case—a small country school where all the classes are under one teacher who is responsible for teaching the entire curriculum. In such a case the *introduction of astronomy into intimate contact with every subject taught* is a more or less domestic problem. For that is what I propose: as the cement, introduced into intimate contact with every part of the conglomerate, does not add to the volume; so astronomy, properly taught, may be brought into intimate contact with every part of the school work, in such a way that it will not add to the time required to cover the curri-

culum imposed. And as the cement consolidates the conglomerate, producing a satisfactory concrete of great strength and resistance; so astronomy may be made, under these conditions, to add strength to the other subjects, increasing the value of the whole course.

As a teacher of mathematics it has often been impressed on me that there is a great waste of opportunity in the matter of the working of problems. My own experience has taught me that I have learned far more by working out a method of attack for a problem arising out of research, and carrying it through to a satisfactory conclusion, than by working dozens of set problems dealing with hypothetical cases. The very need of *stating* your own problem is most valuable. We can bring astronomy into intimate contact with many subjects by using the methods of those subjects to work out the problems which have developed in the observations.

I admit that the preparation of a school programme to permit of this presents difficulties. I shall deal with these difficulties after giving some illustrations of the way in which astronomy may be handled in connection with different subjects of the courses taught in our schools.

The principle of teaching a subject to a pupil as it was acquired by the race is one which has its limitations. In Astronomy it may be applied with some justification. The nomadic races of the earliest times observed the stars. They had few interests. The wonders of the heavens were really wonders to them. When I was quite a small boy one of the families living on the same street had what they called a century plant. One day it bloomed. As a small boy, admitted as a special privilege to view the wonder, I gazed with awe, which I remember to this day, upon a flower which could, as I supposed, be seen but once in a hundred years. Emerson says, "If the stars should appear one night in a thousand years how would men believe and adore and preserve for many generations the remembrance of the city of God which had been shown".

The early observers described the positions of stars with reference to certain mythological figures. The stars in the constellation of Orion are not necessarily related to each other in any way. Betelgeuse might as well have been grouped with Aldebaran and

some other constellation formed. But the ancient philosopher plotted the stars upon the smooth desert sand, and then sketched about them the figure of a giant and the head of a bull. And so Betelgeuse became "the star in the giant's right shoulder" and the red Aldebaran was appropriately known as "the star in the eye of the bull".

So the constellations were grouped and figured in the sky. The patriarchs relieved the monotony of life by weaving stories about these figures. The stories preserved the figures; the figures preserved the position designations; both, for many generations, kept the people looking at the sky and learning to know their way among the stars.

You tell fairy stories in the kindergarten. You use them for composition purposes in all the other grades of school. Why not give some astronomical mythology to the classes of younger students. I quote from *Astronomy with the Naked Eye*, by Garrett Serviss, published by Harper Brothers, New York:

"The mere names of the ancient constellations captivate the mind. Who can look unmoved upon Andromeda, chained, and Perseus, with diamond sword, speeding to her rescue; or upon Orion, lifting his starry club to meet the Bull, charging headlong down the curve of the zodiac? It is a felicity to know Sirius, that great prismatic star that awed the ancient land of the Nile, at his rising, and in whose honour immense temples, the oldest in the world, were erected; or Arcturus, whose power and beauty inspired the poet Job."

The first chapter of this book is full of suggestions such as these. If you really become interested in the mythology you might care to read the book, *Star Names and Their Meanings*, by Richard Allen, published by G. E. Stechert, New York. This is a closely printed book of over five hundred pages. Surely our little ones may learn with safety and with profit the fascinating stories of stellar mythology, and learn to find their heroes in the night skies.

I was much struck with the dedication page of a volume which I have often used with profit, *A Beginner's Star Book*, by Kelvin McKready (Edgar Gardner Murphy), published by G. P. Putnam's Sons, New York. I shall refer to the book again. His dedication is simply

TO
M. AND D. AND G.
WHO HAVE WATCHED WITH ME AT THE THRESHOLD

Can you not see M. and D. and G. and sense the bond that unites them?

"McKready's" widow, Maud King Murphy, has recently published a smaller volume, *A Beginner's Guide to the Stars*.

"McKready" says he asked a man who knew the stars, "How did you first learn to know them?" He replied, "I had a friend". May not some teacher in the kindergarten or public school classes of this city be such a friend whose kindly guidance may give the world another Herschel?

I must digress at this point, from the application of astronomy, to consider in some brief and scattered detail what is meant by a *proper teaching of observational astronomy*.

The astronomy of the Greeks introduced a fundamental idea which may be given to boys and girls at a very early age. They supposed the stars to be fixed upon a glass sphere. They did not think of this sphere as being of at all the great dimensions we now apply to what we call the celestial sphere. Their sphere rotated about the earth once a day. Herein lies a valuable aid to stellar observation by amateurs.

A basic principle is involved in the idea. The sun and moon and stars do not rise and set, yet we find it convenient to say they do. In the early teaching of astronomy let the child grow as did the race, and although you may remind him occasionally that it is a convention only, let him speak of the apparent motions of stars and other celestial objects. He may then, when freed from the difficulties of distinguishing every time between real and apparent movements, build up for himself observation experience upon which he may draw when the formal theoretical explanations are presented to him. These should be presented incidentally, it seems to me, a part at a time, when the student has sufficient experience to enable him to add the fact to his acquired body of formal astronomical facts. For example, the true explanation of eclipses may be presented at an early age, but the true explanation of the movements of the planets might well be left to the

upper forms in high schools. After a pupil has observed for years that Venus is either a morning or an evening star, but never appears high in the midnight sky, he will ask "why"? That is the psychological time to give the explanation. That is what I mean by teaching incidentally.

To come back to the celestial sphere: an important truth which can be really grasped only when approached from several different directions, is the fact that the line from an observer in Ottawa to a given star is, to all intents and purposes, exactly parallel to a similar line from an observer in Toronto (or in Timbuktu for that matter) to the same star, the observations being made at the same instant.

You may approach the idea at an early stage by allowing the child to think of the sky as a glass sphere. Once in a long while only should you have him admit that this is a convention. The idea persisted in astronomy for many, many years. Only a few hundred years ago a monk in Europe is reported to have treasured a fragment of meteor with a vitrified surface which he claimed was a bit broken out of the celestial sphere.

Many children, even small ones, can use a camera. Let them take a long exposure photograph, say for an hour, of the northern heavens, pointing the camera at Polaris. When the film has been developed the stars will be found to have traced out circles about Polaris in the centre, or rather near the centre.

It is easy to explain apparent motion in a reverse direction. Any child would expect to have objects in a picture, photographed at right angles to a moving train, trace lines across the field of view. But how can the stars above Polaris trace the lines in one direction and those below in the other? If you think of the stars as being on a sphere of glass the conception is easy; but if you try to explain it as it is, you will wish your school at the north pole. The basic difficulty lies in this idea of infinite distance and the parallelism of lines of observation. Leave the true meaning to the older classes to grasp after an experience of years, but let the little ones visualize the glass sphere rotating, without disturbing them with the explanation.

When a child has seen a picture, which he or one of his friends took of the north sky, and has then been given a conception of

the sky as a glass sphere, he will understand why the Belt of Orion is vertical when rising and horizontal when setting. The star charts in McKready's book give extremely good views of the sky as seen at different times and from different directions. The view of Orion in his different aspects becomes familiar. A child should learn to recognize the trace, through each constellation, of its *celestial meridian*, if I may speak in such terms of the line through the constellation and joining the celestial poles. This will enable him to recognize his celestial acquaintances in whatever direction they may appear and to find the true north from any constellation. Most of us are familiar with the fact that in the case of the Big Dipper a meridian runs through the two outer stars of the bowl—the Pointers as they are named in consequence of this fact.

Some years ago two boys in this city became interested in the stars. They agreed to spend one evening a week observing and asked for my co-operation. For over a year they came regularly each Friday whether the sky was clear or not. They saw the Pleiades just rising at nine o'clock in the evening in late October. They continued their observations while this group of stars was found further and further westward each week at the same hour. In the spring they bade farewell to this group as it set at nine. They were still carrying on the course, and welcomed the Dancing Fairies when they returned to the night sky in the fall.

After such a series of observations, which could be made without the continued presence of a teacher by the smallest school child, the habit of observing the celestial movements would have been begun. Later in his public school course he might be led to reason that the apparent movement to the westward of the stars might be explained by a possible movement to the eastward by the sun or by what is known now to be the true movement of the earth in its orbit. How many people know that the earth rotates on its axis 366¼ times in a year? The diurnal and annual movements of the earth are usually taught as a piece of information explained perhaps by the use of the helioterra. And certainly that little instrument is most valuable, but it should supplement—not supplant—direct observation on the stars themselves.

You ask how the boys could spend their evenings each week

for a year in such observations. Certainly they did other things. A single constellation was given them at first. After getting the conception of the sky as a glass sphere, they learned that very practical thing which has been mentioned; they recognized the possibility of expressing the sizes of celestial bodies or groups of bodies in terms of the angle subtended at the eye. They recognized the fallacy of stating that the moon is as large as a dinner plate. At first they used a ruler as an art teacher tells a pupil to use a pencil for getting comparative dimensions in a sketch. They realized that the height of a house could not be expressed in terms of the inches on the stick unless you knew the distances to the house and to the stick from the observer's eye. They found, however, by experience, that the first of these distances could vary through fairly wide limits for quite distant objects, and thus approached the idea of an infinite radius for this sphere, and the possibility of getting comparative distances of separation of stars in terms of marks on the ruler, provided that they held it always at arm's length from the eye and perpendicular to the line of sight.

They found from their star maps that the angular separation of the stars at the mouth of the Big Dipper is ten degrees. Then they made a sort of cross-bow with two sticks and a cord. These sticks were flat and thin, especially the one forming the bow. It was bent about an arc of determined radius when soft, after being boiled, and was allowed to set, held in position by one end of the staff of the cross-bow pressing its centre, and the cords joining its end to the other end of the staff. Thus each point on the arc was the same distance from the end of the staff farthest from the bow. They laid off ten degree divisions on the arc, calculating the distances and using India ink for marking. They learned to estimate to tenths when using the device. A pair of cardboard riders on the arc completed the arrangement. The calibration was tested by placing one rider at 0 on the arc scale and the other at ten degrees, and holding the bow with the end of the staff at the eye and the arc parallel to the two top stars of the Big Dipper's bowl.

One advantage of using riders on the bow is that these may be set to just permit both stars to appear in the space between them but no more. There is no need of faint illumination of the bow under these circumstances, and fairly accurate measures

may be made. A flash light permits the determined arcs to be read off and entered in note books.

After testing the device on the Big Dipper other dimensions were measured. They learned to plot positions of bright stars using their cross-bows, and to say that a certain star was a given number of degrees from Polaris and so many from Aldebaran. They could thus determine its name from the star map. Thus they plotted constellations to scale by triangulation. They made use of the check quadrilaterals, as is done in geodetic surveying, and learned the fact that of all rectilinear figures the triangle alone is fixed when the lengths of its sides are given. Such a fact, learned unexpectedly in observation, is driven home with some of its full significance.

On cloudy nights the boys plotted star maps. They soon realized the value of a globe. It is unfortunate that celestial—and terrrestrial—globes are not available in every school room. Children should learn that the maps cannot give mileage over long arcs. Radio fans measure the distance from Ottawa to Los Angeles on a flat map. They do not obtain accurate distances. But that is not all. If they are using a direction aerial they would never think that Los Angeles is exactly west or perhaps a little northwest from here. They might doubt me when I say that Australia is exactly northwest of Ottawa, or that the shortest distance from Ottawa to Tokyo lies through Behring Straits. These things should be made familiar to a boy in public school. Only with the help of a good globe can it be done.

The boys studying astronomy with me had to make shift with flat maps, but they managed to grasp the fact that the maps *were distorted*. You cannot drape a fat man's suit on a cardboard dummy of equal height and width and have a perfect fit. Neither can you take a pattern from the garments of Mother Earth—a world map—and have it lie perfectly flat, all in one piece, as does Mercator's projection of the world, without having distortion.

In plotting maps the boys learned of the conventions of right ascension and declination circles on the celestial sphere, serving the same purpose as our longitude and latitude circles on the earth. As they plotted the constellations nearer the pole the distortion became worse, and they were forced to use circular

maps with the pole of the heavens in the centre. No one may plot the continents from observation, but pupils of sufficient age and experience may do a similar piece of work in the case of the stars—and from direct observation.

They learned that the constellations, defined by the fanciful figures of the ancients, have been more accurately bounded by modern astronomers. But the old figures have been remembered, and the old names have been retained for the constellation names and for some of the star names as well. To designate all the visible stars—about 5,000 throughout the whole heavens are visible without the use of a telescope or other aid, though less than half may be seen at any one time—another system of naming must be employed. This was done by giving the brightest star in the constellation the name Alpha, the next, Beta; and so on throughout the letters of the Greek alphabet. When the Greek letters become used up the Roman ones are used in order. This method of designating the stars is used in most star maps. In technical practice the stars are defined in position in certain catalogues, giving their right ascension and declination position as one would give the longitude and latitude of places on the earth. The serial number given the star in a catalogue, together with the name of the catalogue is used to designate it, as *Groombridge 1830*. So the boys plotted the constellations, especially those about the ecliptic.

We have spoken of the magnitude of the stars in connection with their letter names. The matter deserves the attention of the teacher. The average brightest stars are called first magnitude. The faintest, just visible to the naked eye, are called sixth magnitude. The intermediate magnitudes are determined by dividing the difference in the amount of light received from a first magnitude star and that received from a sixth magnitude star into five equal parts, and placing the magnitudes one to six according to the resulting scale. The fainter the star, the larger is the number denoting its magnitude. Stars may be, and most are, of fractional magnitude; that is to say, few fall exactly upon the integer positions of the scale. The work of *accurately* determining the magnitude of a star is a difficult piece of work. The boys learned to do it approximately by comparing a star to be

estimated with one or two others in its immediate neighbourhood whose magnitudes were given in McKready's book. After the estimate had been made it was compared with the figure given in the book for that star. The practice develops an experience and skill which is of serious scientific value.

At irregular intervals a new star or Nova appears here and there in the heavens, usually in the neighbourhood of the Milky Way. This is usually a star, known to have been there before, but very faint, in most cases invisible to the naked eye. It may reach first magnitude or brighter in a few hours. Then it fades slowly. If we plot the fading, intensity against time, we find the star has periods of recurrence of brightness. The data for such plots may be obtained by observations such as those made by the boys. They are of particular value when a Nova is nearly at its maximum, that is to say, throughout the first two or three days. The discovery of a Nova is one that anyone can make who knows the first and second magnitude stars well. There are only some 20 first and 65 second magnitude stars in the whole sky. The number visible at any one time and near the Milky Way is much more limited. The last great Nova appeared June 8, 1918. The brightest one appearing for some time previous to this was Nova Persei, which reached a maximum on February 23, 1901. Stories about these Novae are very interesting. Nova Aquilae—the 1918 one—appeared during an evening when many noted astronomers had just settled down after a busy day photographing and observing a total solar eclipse. Imagine, if you can, their surprise and delight, on noting a new star in Aquila—the brightest Nova that had appeared in more than three hundred years. There was a touch of romance about it. The first to discover the celestial stranger was Mr. Warren Cudworth of Norwood, Mass., who telegraphed the news to Harvard in time that photographs could be made *before* maximum. But anyone familiar with the constellation could just as easily have made the discovery had he happened to be looking at the stars that evening. At the present time there is a new star in the southern sky which was discovered at 5.50 a.m., on May 25 last, by Mr. R. Watson, of Beaufort West, South Africa, when on the way to his work in the post-office. Mr. Watson was also an independent discoverer of Nova Aquilae in 1918.

The boys and girls can develop skill in such magnitude observations by practising on variable stars which can be seen whenever that part of the sky is in view. These pass through variations in intensity covering several magnitudes, with periodicities of from a few days to months. Algol is perhaps best suited for these observations, being visible in the early evening in the months of October and November. It passes through a cycle in a little over 2 days and 20 hours. Normally of the second magnitude, it loses five-sixths of its light when at the minimun, due to eclipse by a dark companion. Comparing Algol with stars of known magnitude in the immediate neighbourhood and plotting the results from night to night, will enable the pupil to determine the time of minimum which can be checked from tables.

Other lines of observation might be outlined, such as the plotting of the apparent motion of a planet among the stars—a matter requiring perhaps five minutes observation once a week on the part of each pupil—or the observations at solar noon showing how the sun varies in declination—an observation which could be taken at any south window in the school in a few minutes once a week. These and other practical observations are discussed in a book called *Laboratory Astronomy*, written by Robert Willson, and published by Ginn and Co., New York.

Have I made clear what I mean by the laboratory method of teaching astronomy? How may it be associated with other studies? In composition you may read and reproduce stories of real interest to children, from the myths of the ancients up through the ages of unrest and discovery to the achievements of today. In manual training you can have simple equipment for observing made with precision, as indicated in Willson's book. Why not make a sun dial and use it to determine in what way solar and mean times differ?

In art you can have the pupils measure and plot a constellation and then sketch in the mythological figure. *One* such piece of work would stimulate many a child to lifelong observations of the skies.

In history you could include such stories as the persecutions of Galileo to show how the dark ages treated observational science. He says, "It appears to me that they who, in proof of any assertion,

rely simply on the weight of authority, without adducing any argument in support of it, act very absurdly. I, on the contrary, wish to be allowed freely to question and freely to answer without any sort of adulation, as well becomes those who are sincerely in search of truth."

Are you teaching physics? It was Galileo who said to those who objected to his theory of falling bodies, "If you do not believe that a ten pound weight takes the same time to fall to the ground as does a weight of one pound, let us go to the top of the tower—the leaning Tower of Pisa—and let them fall". In spite of their reluctance to do it he managed to get the whole staff of the university and the students to witness the test. The two objects were released together, together they fell, and together they reached the pavement. But the professors, with the united crash of the two weights sounding in their ears, turned away, quoting chapter and verse of their authority, Aristotle, to prove that the heavier weight fell ten times as fast as the lighter. If you want more of this read the book *Galileo, His Life and Work*, written by J. J. Fahie, and published by John Murray, London.

Consider the classics. In giving an exercise, choose once a bit from Copernicus or from Newton—not much, but a few sentences to let the students know there are such books and get the general method of their presentation. Perhaps the modern languages are your subject. Poincaré, for example, wrote much that is easy to read if you are referring to the subject matter. Why not let the students get a taste of it as a respite from their regular French. The time will not be lost. If they have an interest in astronomy it will carry over to the French, and *vice versa*.

Astronomy works in well with mathematics at all school ages. The small child who has learned the shape of the Big Dipper can plot the outline from copy, learn how it rotates about the pole star, and note that the four stars of the bowl and the three of the handle make seven. It is a nice problem in " busy work" as we used to call it to see how many triangles they can make by joining the stars in threes. Use observational material from the second or third book pupils' work for compound addition problems in degrees, minutes, and seconds. Or in ratio: give them the distances from the sun to the planets and to a fixed star, and let

them determine the relative distances on the scale that the distance from the sun to the earth be represented by one inch.

When they have done it give them Bode's law and they will never forget its beautf ıl simplicity, probable absence of any basis but chance, and value in discovery. His law is beautifully simple. Write the numbers 0, 3, 6, 12, 24, 48, etc., according to the obvious rule of getting the next by doubling the last one already written. Then add four to each getting the numbers 4, 7, 10, 16, 28, 52, etc. Place a decimal point before the last digit in each, and write above the numbers the symbol designating the planets in order, Mercury, Venus, Earth, Mars, etc., but skip one at 28. Then the 1 below the ⊕ for Earth indicates that the distance from the earth to the sun is to be taken as the unit. The distance of Venus from the sun is seven-tenths of this, and so on. After the plotting problem has been done they will remember the story of why there was supposed to be no planet at position 2.8; of the discovery of Uranus and the planetoids according to this law, and of the retardation in finding Neptune because it fails to obey it; of the differences in type between those planets at positions less than 2.8 and those at positions greater. That is the psychological moment to drive home this truth of the value of rules without basis—of untrue hypotheses.

Astronomical observations will furnish mathematical problems which may be discovered, stated and solved by the pupils in geometry—similar triangles for example—and in plane trigonometry. Time fails to continue further the applications to mathematics.

Are you teaching dramatics? Why not let the pupils dramatize the recantation of Galileo. Forced to say he did not believe the earth to be stationary and the centre of the solar system, he did it, but muttered as he turned away, "Nevertheless, it moves". If teaching aesthetic dancing, put on the Dance of the Pleiades.

If I have omitted showing how the particular subject you are teaching may be combined with some part of astronomy, so as to pique the interest of some pupil or pupils in such a way that they may afterward begin to make astronomical observations for themselves, I will go so far as to say that, given the subject

and the age of the pupil, I think I could find a point of contact; at all events I would try to.

Now how can we arrange for the teaching of the subject in the schools? If we had what I may call a *circulating* teacher of astronomy, as we used to have for music, he could evolve a programme which could be adapted to the schools, and in time the teachers of astronomy would be trained as have been the teachers of music.

The present appeal is that each in his own place will try to work in some real observational astronomy with his or her work. The method to be followed would be much the same whether one is preparing a programme for a class, for a school, for a city or for the province. First choose your material to be taught. Then arrange it in such a way that all the underlying principles which present difficulties are come upon only one at a time, the least difficult and least complex first. Plan the programme, fitting it to the school year so that the observations required are in accordance with the annual stellar cycle. Design a system of recording so that the incidental teaching can be preserved to make an orderly body of observational data which may, later in the year, be correlated and reduced to formal order. Make for yourself a planisphere and teach the pupils to use it. Leave it where they can use it freely. Read more than you intend to teach, different material and from different books each year. Avail yourself of the services offered by the Astronomical Society. Besides publishing a monthly journal they distribute gratis to members a yearly Handbook giving details of all the astronomical events of the year, such as eclipses, variations in intensity of Algol, occultations of planets, moon phases, planet configurations and many more. You are also privileged to ask questions at any meeting either on the subject in hand or on any other, and to have your problem discussed and a satisfactory solution obtained, if possible.

At the beginning of this lecture—and I fear in spite of my petition for indulgence that it has seemed like a lecture—I outlined a few reasons for which astronomy should be studied because of its fact-content. Now, having explained my views—which are really not mine but a collection of the views of many, interested in astronomy—I wish to point out the cultural benefits to be derived from the subject.

The skies are the same for all. The material for examination is precisely the same for each pupil. The equipment required can be made by the pupils themselves. Most of the observations may be made without the presence of the teacher and one at a time. The teacher has here at his ready command the best of material to develop the spirit and the methods of scientific research.

The spirit of scientific doubt may be cultivated. After a series of observations which show that the new moon is always wet each September, and always dry each March, and varies through a cycle with perfect regularity, the pupil will need no further proof that it cannot be the cause of excess or lack of rain. He will learn, as some are just coming to learn, that the stars do not affect our lives—"The fault is with ourselves not with our stars that we are underlings". Astrology served a useful purpose, in spite of its errors, by encouraging observation.

He will learn to make use of rules of thumb to keep track of astronomical phenomena, and to distinguish between these and Bode's Law for example. I refer to the simple method of determining time to within a quarter hour from the Big Dipper, as described in the October, 1925, number of the JOURNAL of the Royal Astronomical Society of Canada, where you consider the north sky as a clock face with the 6 hour point at the north horizon. You read time to the nearest quarter hour from the pointers, add as many hours to the nearest quarter as there are elapsed months to the nearest quarter since January 1, and subtract the result from 16¼—or from 40¼—obtaining the time to the nearest quarter hour, p.m.

A spirit of scientific inquiry will be developed. After a boy has observed a sun spot traverse the solar disc, and calculated the period of solar rotation he may be asked to repeat the experiment with the moon. The markings are there. Why do they not rotate so as to present new areas to the earth? The problem is his. He found it himself. He can solve it too if left alone. And what a gain! It is much more than the information acquired.

When a boy has had a long course of observing spread over some years of his school life it is time to tell him that, much as he can see with the naked eye, the telescope reveals more: photographs with the telescope still more, especially with long exposures

which reveal stars the eye will never see with the aid of any telescope: the spectroscope and the spectroscope combined with photography go farther yet. He can learn that the faint object he called the Andromeda nebula may be studied in greater detail with the aid of these instruments in the hands of skilled men. He may obtain a faint idea of the immensity of creation when he gets the conception that the solar system, great as he has found it to be by his own experiments and observations, is as a speck in the stellar universe; that the stellar universe is possibly somewhat of the same shape as the nebula in Andromeda; that the nebula themselves are perhaps other stellar universes—and so on and on.

We are becoming very matter-of-fact now-a-days. We need to retain some incomprehensible immensities that are the same, unchanging and unchangeable, to inspire that feeling, almost unknown today, of awe and wonder. A carefully selected course of observational astronomy, carried on along the lines indicated, will go far to develop the feeling of which the Psalmist spoke when he said: "When I consider the heavens the work of Thy fingers, the moon and the stars which Thou hast ordained, what is man that Thou art mindful of him, or the son of man that Thou visitest him?"

THE GALACTIC DISTRIBUTION OF THE PSEUDO-CEPHEIDS

By F. Henroteau

ALL super-giant stars of classes A, F, G, K, or stars of very low density and high surface brightness, which are not variable stars of the cepheid type and usually of constant brightness, are called pseudo-cepheids, a name which was first assigned to them by Professor Adams, Director of the Mount Wilson Observatory.

A table of Professor Adams' Pseudo-Cepheids was published by the writer in an article on the Cepheid Problem.[1] Since the appearance of the memoir by Dr. R. K. Young and W. E. Harper on "The Absolute Magnitudes and Parallaxes of 1,105 stars"[2] the number of pseudo-cepheids has been enlarged. There are very few pseudo-cepheids as compared to other stars, but their interest is very great, considering their super-giant nature and their small parallaxes. A study of their galactic distribution is important and might give us some rough idea as to the structure and the size of our sidereal universe.

Following is a table of the pseudo-cepheids, combining those discovered by Adams and by Young and Harper, to which are also added Alpha Cygni and Sigma Cygni. It may be said that the stars studied by these astronomers have been chosen largely at random, so that the resulting distribution of pseudo-cepheids can be of great interest. The galactic longitudes and latitudes of these stars have been computed by the writer, the position of the galactic pole adopted being R.A. 12h 42m, Decl. +27°, the longitudes being reckoned from the ascending node on the equator, in the direction of increasing right-ascensions.

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[1]Dom. Obs. Pub., Vol. IX, p. 15.
[2]Dom. Astroph. Obs. Publ., Vol. III, No. 1.

TABLE OF PSEUDO-CEPHEIDS AND THEIR GALACTIC CO-ORDINATES

Star	1900.0	1900.0	Gal. Long.	Gal. Lat.	Spectral Class	m
	h m	° ′	° ′	° ′		
76 Piscium	1 0.7	+31 39	94 39	−31 12	K4	6.6
H.R. 690	2 16.9	+54 55	103 28	− 5 37	G5	6.5
14 Persei	2 37.5	+43 52	111 2	−14 22	G1	5.6
17 Persei	2 45.4	+34 39	117 0	−21 47	K4	4.7
H.R. 865	2 49.8	+46 45	112 39	−10 19	K3	6.1
α Persei	3 17.2	+49 30	114 9	− 6 5	F5	1.9
58 Persei	4 29.7	+41 4	129 16	− 3 58	G1	4.5
β Camelop	4 54.5	+60 18	116 45	+11 12	G0	4.2
ϵ Aurigae	4 54.8	+43 40	130 19	+ 1 23	F2	3.4
α Leporis	5 28.3	−17 54	188 30	−24 1	F4	2.7
46 Aurigae	6 17.2	+49 20	132 32	+16 23	K2	5.1
ϵ Gemin.	6 37.8	+25 14	156 47	+10 19	G9	3.2
41 Gemin.	6 54.5	+16 13	166 25	+10 2	K2	5.9
δ Can. Maj.	7 4.3	−26 14	205 50	− 7 4	G2	2.0
ξ Puppis	7 45.1	−24 37	209 4	+ 1 47	G6	3.5
ρ Puppis	8 3.3	−24 1	210 41	+ 5 38	F7	2.9
29 Monoc.	8 3.6	− 2 41	191 45	+16 52	G1	4.4
298 G. Puppis	8 18.6	−26 2	214 6	+ 7 21	F5	5.9
Boss 2437	9 0.2	+38 51	150 55	+42 47	G3	4.7
H.R. 3850	9 35.7	+31 43	161 48	+49 28	K6	6.1
9 Draconis	12 56.2	+67 8	87 52	+49 49	K0	5.5
H.R. 5448	14 30.5	+37 4	30 14	+65 6	K5	6.2
Boss 3740	14 34.5	+44 4	44 27	+61 38	K2	5.9
2 Serpentis	14 56.7	+ 0 14	325 53	+47 59	K2	5.9
Boss 3860	15 4.2	+25 29	5 7	+58 13	K2	5.9
Boss 4048	15 50.2	+20 36	0 48	+46 43	K4	5.8
Boss 4207	16 26.2	+20 42	5 7	+38 50	G5	5.3
Boss 4329	16 56.7	+22 47	11 49	+32 41	K2	5.7
β Draconis	17 28.2	+52 23	46 50	+32 9	G0	3.0
θ Herculis	17 52.8	+37 16	30 27	+25 58	K1	4.0
105 Herculis	18 15.1	+24 24	19 16	+16 26	K2	5.5
Boss 4795	18 50.4	+42 45	40 5	+16 30	K9	6.9
Boss 4817	18 53.8	+17 14	16 40	+ 5 6	F8	5.4
λ Lyrae	18 56.3	+32 0	30 27	+11 11	K4	5.1
π Sagittarii	19 3.8	−21 11	343 8	−14 4	F4	3.0
θ Lyrae	19 12.9	+37 57	37 26	+10 40	K3	4.5
22 Vulpeculae	20 11.2	+23 12	30 54	− 7 35	G7	5.4
α' Capricorni	20 12.1	−12 49	0 0	−25 40	G0	4.6
Boss 5205	20 13.4	+40 3	45 5	+ 1 33	K5	5.5
35 Cygni	20 14.8	+34 40	40 53	− 1 47	F7	5.2
γ Cygni	20 18.6	+39 56	45 34	+ 0 38	F7	2.3
ρ Capricorni A	20 23.2	−18 9	353 43	−30 16	A9	5.1

TABLE OF PSEUDO-CEPHEIDS AND THEIR GALACTIC CO-ORDINATES

Star	1900.0	1900.0	Gal. Long.	Gal. Lat.	Spectral Class	m
	h m	° ′	° ′	° ′		
41 Cygni	20 25.3	+30 2	38 23	− 6 19	F6	4.1
α Cygni	20 38.0	+44 55	51 41	+ 0 48	A2	1.3
Boss 5416	20 58.5	+39 6	49 45	− 5 51	K2	6.5
ξ Cygni	21 1.3	+43 32	53 25	− 3 13	K4	3.9
σ Cygni	21 13.5	+38 59	51 45	− 7 59	B8	4.3
Boss 5472	21 14.3	+55 22	63 23	+ 3 33	K5	6.2
ζ Capricorni	21 21.0	−22 51	354 16	−44 31	G1	3.9
β Aquarii	21 26.3	+ 6 1	14 45	−39 8	F8	3.1
γ Capricorni	21 34.6	−17 7	0 0	−45 44	F4	3.8
ε Pegasi	21 39.3	+ 9 25	33 4	−32 41	K2	2.5
α Aquarii	22 0.6	− 0 48	27 15	−43 14	F9	3.2
H.R. 8445	22 4.3	+49 18	65 25	− 5 58	K2	6.9
ζ Cephei	22 7.4	+57 42	70 29	+ 0 4	K3	3.6
H.R. 8519	22 16.6	+50 28	67 44	− 6 5	K2	6.6
Boss 5797	22 24.1	+ 8 38	41 50	−41 14	K3	5.8
5 Lacertae	22 25.4	+47 11	67 18	− 9 44	K2	4.6
H.R. 8692	22 45.9	+50 9	71 42	− 8 38	G5	6.4
Boss 5931	22 55.9	+56 24	75 42	− 3 37	G3	5.5
56 Pegasi	23 2.2	+24 56	62 52	−32 49	K2	5.0
89 Aquarii	23 4.6	−23 0	356 25	−67 40	F8	4.9
ρ Cassiop	23 49.4	+56 57	80 9	− 4 39	G6	4.8

The positions of the stars in this Table have been plotted on the accompanying graph, taking the galactic longitudes as abcissae and the latitudes as ordinates.

Between longitudes 40° and 220° they show a strong condensation toward the galactic plane, with very few discordances. In Cygnus (40° to 80°) the condensation is very marked.

To the left of longitude 40°, however, they decidedly branch off toward the north and toward the south. The most remarkable fact is that this branching off is coincident with the separation into two branches of the Milky Way itself, that well known fork which is so plainly visible on clear moonless nights.

A former study of the distribution of about 6,100 stars, all brighter than magnitude 6.25, among which no doubt practically all the F, G and K stars are dwarfs, gave the following table for mean galactic latitudes.[1]

[1]Harvard Annals, Vol. 64, p. 144 See also The Adolpho Stahl Lectures, p. 226.

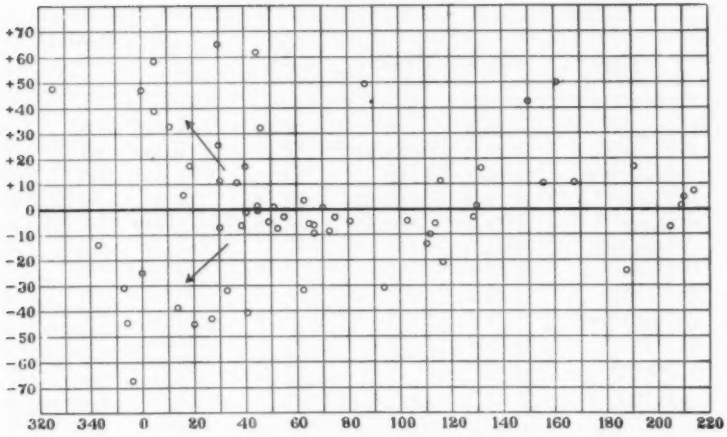


Fig. 1. —Galactic Distribution of Pseudo-Cepheids.

Galactic Latitude	B	A	F	G	K	M	Total
62°.3	37	296	156	128	378	101	1096
39°.8	85	345	152	128	377	108	1195
21°.6	227	539	200	170	559	126	1721
8°	367	705	212	183	505	122	2094
Totals	716	1885	720	609	1729	457	6106
Galactic concentration or ratio for 5° and 80°	20.0	3.0	1.6	1.6	1.5	1.5	2.2

The brighter dwarf stars of classes F, G and K are distributed very nearly at random over the celestial sphere; being on the average much nearer than the super-giant pseudo-cepheids examined, their distribution has not yet espoused the general shape of the Milky Way. The distribution of the pseudo-cepheids begins to espouse this shape; the great opening of the fork indicated on the accompanying graph, which is much larger than the opening of the Milky Way Fork, is due no doubt to the fact that the pseudo-cepheids investigated are the very nearest stars of the Milky Way, as might have been supposed.

At galactic longitude 10°, the average half-separation of the two branches of the Milky Way is about five degrees. At the same galactic longitude the average half-separation of the two branches of the accompanying diagram is about forty degrees.

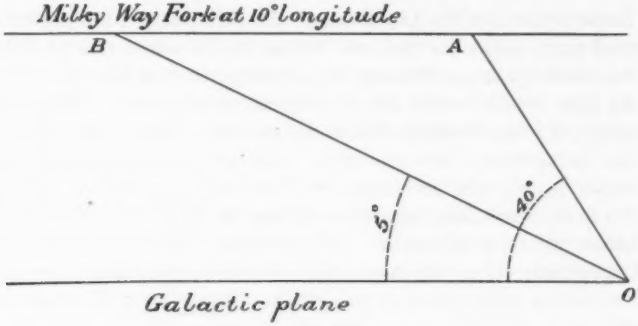


Fig. 2.

If Δ is the average distance of the pseudo-cepheids, and if it is assumed that the two branches of the Milky Way at 10° longitude extend in planes parallel to the galactic plane, from the accompanying graph can be made a rough computation of the average distance of the stars in the branches. *O* is the observer on the earth, *OA* the direction of the average pseudo-cepheid at 10° galactic longitude, making an angle of 40° with the direction of the galactic plane; *OB* is the average direction of the stars in the branch of the Milky Way at 10° galactic longitude; *OB* makes an angle of 5° with the galactic plane

$$OB = \frac{OA \sin 40°}{\sin 5°} = \frac{\Delta \sin 40°}{\sin 5°}.$$

From a consideration of the parallaxes of the pseudo-cepheids it may be assumed that Δ is only a few hundred parsecs. If it was, for instance, 1,000 parsecs or 3,260 light years, *OB* would be approximately 24,000 light years, a distance compatible with the estimated dimensions of our sidereal universe.

THE NEW (BOMBARDMENT) THEORY OF THE AURORA*

By A. F. Hunter

Some years ago the Librarian at the Edinburgh Medical School wanted more space for the new books; so he asked the professors of the School, each in his own department, to give him lists of the books that could be put away to make more room. The answer he received from Professor Simpson was this: "Put away all books in my department into the attic that are over ten years old". In other words, the advances in Medical Science were so rapid that a book more than ten years old was of little use. This is true of nearly all other sciences. It is an actual fact that those who had their first schooling in physical science thirty years ago, have had to revise their ideas at least three times—once for every ten years.

They had no sooner left the lecture halls (within the next five years) than the photographic property of cathode rays was discovered. About ten years later, came the discovery of Uranium, Radium, Polonium and other radio-active elements. Ten years more and all the elements were broken up into electrons and protons, and scientists also found that there could be only ninety-two elements.

This example of cathode rays has been given, because they are connected with the aurora, the connection between which is the subject for this paper. To state the case differently—the invention of the Crookes' Tube, which gives the cathode rays, was the beginning of a new era in physical science, just as the invention of the telescope, the spectroscope and dry-plate photography successively opened new eras in astronomy.

Outer space beyond the atmosphere has its counterpart in the high vacuum of the Crookes' tube, in which are produced the cathode rays. An important feature of the *B* particles or electrons which produce these rays is that they are attracted by magnetized bodies. This is one of the fundamental principles of auroral

*A paper read before the Society, at Toronto, October 28, 1924.

action. Fortunately, these cathode rays, which are absorbed in air at a short distance from their source, are formed at the top of the atmosphere, otherwise their destructive effects during an aurora would soon result in the extinction of life on the globe.

Soon after the discovery of cathode rays, Prof. A. Paulsen, a Danish investigator, suggested that electrons, discharged from the sun, are the cause of the aurora, being acted upon by the earth's magnetism. The altitude at which the aurora occurs was measured by Professors Stormer and Birkeland and found to be from about 92 kilometres upward.

What is there at that altitude that electrons can bombard, when shot from the sun or from the top of the atmosphere farther west, and drawn down by the earth's magnetism? It is unlikely that the nitrogen and oxygen of the atmosphere are congealed at any part of the upper atmosphere.

Far to the westward where the sun is still shining, after it has set for us, the solar radiation at the top of the atmosphere drives electrified particles into the darkened shadow of the earth. These electrified particles, in turn, strike against the thinly distributed molecules or atoms at the outside of the atmosphere, and disrupt them as they do in the Crookes' tube. The scale of these operations is vastly greater than that of the Crookes' tube, when upright streamers from 50 to 100 miles high can be formed in the aurora.

Let us consider for a minute the electric condition (statically) at the top of the atmosphere. The earth's surface and the lowest parts of the atmosphere, it is usual to say, are negative. The atmosphere contains clouds, and is only a partial conductor, yet it is a conductor as well as an insulator. At the top of the atmosphere the electric condition must, therefore, be a negative one, the same as at the bottom, because like kinds of electricity repel each other, and are distributed at opposite sides of a partial conductor, with positively electrified regions between them.

The difference of potential between the earth and the intermediate parts of the atmosphere is very great. This difference has been estimated at 2,000,000 or 3,000,000 volts, and more recently at 100,000,000 volts. Lightning shows that the voltage is very great, because a charge of 10,000 volts is required to disrupt every inch of dry air. The lowest estimates of the total voltage given

above are based upon the fact that atmospheric electricity increases at the rate of about 40 volts for every foot of rise, and this continues to an altitude of about ten miles—the highest positions of the lower clouds.

It would appear that electrified particles are driven from the westward at the top of the atmosphere, and bombard the more stationary atoms above us, breaking them up into their parts. Electrons, one of these parts,—are always negatively charged. A portion of these, on being liberated where the upper parts of the atmosphere are already charged negatively, are repelled aloft, and form the towering streamers that we see during an aurora. The residual parts of the atoms, called the protons, are not so productive of light as the smaller electrons shot aloft, but they probably produce the coloured tints which we see at the base of an aurora.

The drapery forms that we see in many auroras can also be easily explained. The very lofty clouds of the atmosphere, which are invisible to us from the ground, but are seen by balloonists and mountain climbers, are bombarded by the streams of particles from the westward and often give the form of curtains or hanging draperies. At times its appearance is that of a horizontal stream threading its way amongst very high clouds. At other times it makes a straight arc of light. The highest cloud forms visible from the ground in actual daylight, especially in the early morning and the late afternoon, bear a close resemblance to the auroral forms, viz.,—long horizontal streamers stretching across the sky like the auroral arc, cirrus wisps, grey mares' tails and mackerel sky.

A distinct tendency toward a maximum of the aurora occurring about two hours after sunset, is often observable. Thus, auroras often follow around after the sun, and are not dependent upon any meridian of the earth's surface. At the top of the atmosphere above the sunlit half of the earth, day by day, there is a slight representation of what takes place at the surface of the sun on a vastly greater scale. The top of the atmosphere above the illuminated side of the earth is bombarded by the solar radiation, particles being driven beyond the edge into the darkened shadow. Marconi's observation of the daily change of the course of wireless waves at noon furnishes us with an example of this motion at the top. (See "Monthly Star Map" for September, 1924). The

magnetism of the earth draws this extended solar radiation into streams, or auroral arcs. Whenever an auroral arc passes overhead, we can often see it flowing horizontally to the eastward like a stream. The upright streamers do not always show this phenomenon, because of their interruption by the upper clouds. It is the flow of particles away from the sunlit hemisphere that produces this phenomenon, sometimes visible in an aurora.

An intimate connection between solar radiation and the aurora thus becomes evident, as well as the importance of the discovery of how atoms may be broken up, which resulted from the perfection of the Crookes' tube.

The counterpart of the aurora, which is essentially connected with the top of the atmosphere, is the thunderstorm at the bottom of the atmosphere. At the top we see the brush discharge into outer space,—at the bottom we see the disruptive discharge into the earth.

The planets, Venus and Mercury, which are closer to the sun than our earth, and therefore receive greater solar radiation than we receive, naturally present appearances of auroral action better than anything we have here on the earth. Radiation from the sun is variable from hour to hour; and, in addition, its distribution over a spherical surface, such as a planet, adds another source of variation.

At the surface of Venus, the intensity of the solar radiation is twice that at the surface of the earth. Accordingly, the appearances that are regarded as elevated tracts of great height at each pole of Venus are evidently auroral in their nature. Some have called them the "Cytherean Alps", but they are quite ephemeral. They doubtless are mere collars of auroral action. At the top of the atmosphere of Venus, wave follows wave of solar radiation as the pictures of the planet show.

Mercury receives solar radiation just seven times more intense than the solar radiation at the earth's surface. We know th s because the radiation varies inversely as the square of the distance. On the other hand, the exposed surface of the earth is eight times greater than that of Mercury. So the total radiation received is about the same on each planet, but in the case of Mercury it is distributed seven times more intensely over a smaller orb.

So great is this radiation at Mercury's short distance from the sun, that rifts on its surface are much more numerous than on that of Venus. Some astronomers have named the markings of Mercury, but they are transient. A map of these markings can be seen, with their names, in *Nelson's Encyclopedia*, for example. Bars are also visible on Mercury, showing phenomena similar to what may be seen on the earth when the maximum of aurora is reached about two hours after sunset. There are also markings which show that solar radiation is carried around from the other side of the planet when that side is more illuminated than the side toward us. On Mercury, then, wave follows wave of radiation, and their influence is sent partly over the dark portion of the disk, just as it is on the earth, but in much greater intensity.

LUNCHEON TO DR. AND MRS. J. S. PLASKETT

The Men's Canadian Club of Victoria and the Women's Canadian Club united with the Victoria Centre of the R.A.S.C. in giving a luncheon at which Dr. and Mrs. J. S. Plaskett were the guests of honour. The luncheon was held at the Empress Hotel, Friday, September 25, 1925.

By special request Dr. Plaskett has furnished the JOURNAL with the address he made, omitting some personal and local references. After expressing his appreciation of the honour done him he stated that he considered the luncheon to be a tribute to the work of the Observatory, to his colleagues, and to his wife, rather than to himself personally. He then continued as follows:

However, I will attempt to tell you something of the purpose and results of my scientific visit to England, so far as it is possible to be of general interest, and will try not to bore you by minute technical details. Many of you doubtless know that I went abroad partly to complete the Fellowship in the Royal Society to which I was elected in 1923, but obtained dispensation from completing the requirements of election until I should be in England. The simple ceremony necessary to validate the Fellowship consists in proceeding to the platform in the Society's meeting room in Burlington House, at which sit the President (at present Sir Charles Sherington), and two secretaries, in signing the roll of the Royal Society containing the signatures of England's most famous scientific men of the past 250 years. The President then shakes your hand and pronounces a pleasant formula, something after this order, "I herewith admit you to all the privileges of and fellowship in the Royal Society". On this particular occasion, June 18, the meeting was fuller and more representative than usual, as beside the English Fellows there were present foreign associates and other distinguished visitors. After the meeting I went, as the guest of the Astronomer Royal, Sir Frank Dyson, to an informal but very pleasant dinner of the Royal Society Club, where I had to say a few words of appreciation.

But the main reason for my visit to England was to attend

the second triennial assemb y of the International Astronomical Union, held at Cambridge, July 14 to 22, the first being held at Rome in 1922, and the third to be in Holland in 1928. This Union, with other scientific organizations, replacing somewhat similar pre-war bodies, was established by the International Research Council at Brussels in 1919. The Astronomical Union includes in its membership all the allied and neutral countries, but not the Central Powers. This exclusion of enemy countries was natural and right at the time of formation, but in the opinion of the majority of the members, including practically all English and American Astronomers, the time has come to let down the bars and admit every country. The Union cannot be truly international nor can it truly represent astronomy, and it is standing in its own light, until Germany and Austria are members. Unfortunately no change can be made in the statutes until the parent organization, the International Research Council, takes action. At a meeting of this body early in July, at Brussels, where England and America had only small representation, this action was blocked. At the Cambridge meeting an expression of opinion was asked, with practically unanimous declarations in favour of the admission of the Central Powers, France, Belgium and the Balkans inserting the provision that admission should not occur until the enemy countries had joined the League of Nations.

The work of the International Astronomical Union is carried on by standing committees, of which there are about thirty, each committee dealing with some special phase of astronomy, and composed of the most eminent experts in that phase. Although there are general assemblies of all the delegates, these are chiefly for confirming and legalizing the decisions of the various committees. None of the work is performed, as is so often the case at conventions, by the presentation of papers; but the Union acts rather as a kind of astronomical clearing-house, to settle debatable questions and standardize methods and procedure. It deals, hence, not so much with new work, but rather discusses and decides questions that are bound to arise in work already done, which no single astronomer or group of astronomers is competent to settle. Some examples may help to render the functions of the Union more understandable.

The question of the boundaries of the Constellations was warmly debated, and progress was made towards clearly defining them, so that no ambiguity in locating any star in its constellation may arise. This is only of importance to the professional astronomer in the naming of new and variable stars, but is of great interest to the amateur.

The Committee on Notations and Units adopted standard definitions and symbols for various astronomical units, an important step towards securing uniformity in discussion and publication.

The Committee on Wave Lengths made important decisions on questions of suitable standards of wave length and their methods of production, and adopted values of the wave lengths of certain neon and cadmium lines. It may be remarked in passing that these wave lengths are about one fifty-thousandth of an inch long, and are correct to about one part in five million, the actual length of the wave being correct then to one five-millionth part of one fifty-thousandth of an inch. This may seem an excessively small quantity, but it is a very fundamental and extremely important one in all physical science.

The Committees on Solar Rotation and Solar Physics also standardized procedure, and adopted recommendations of great importance owing to the vital part played in terrestrial affairs by the radiation from the sun.

Committees on Meridian Astronomy, on Time, on Stellar Parallaxes, on Stellar Photometry, on Double Stars, and the three committees of which I was member, Stellar Classification, Radial Velocities and Variable Stars, also made important recommendations and advances, but the work is too technical for description here.

The important question of Time was discussed by a joint committee composed of members of several allied committees. As you all know our civil day begins at midnight, but prior to January 1, 1925, the astronomical day began at noon, 12 hours later than the civil day. That the day is determined by the motion of the sun which crosses the meridian at noon, and which hence should be zero hours and the beginning of the day, is the principal reason for this difference. The resulting confusion, especially for navigators, led to the change last New Year's, so that now astro-

nomical and civil time are coincident, resulting in happiness to the layman and sailor, but worry to the professional astronomer who has to change his methods of recording time and to remember the loss of 12 hours last New Year's.

You all know what a troublesome process it is to determine the number of days between any two dates; you have to remember the number of days in the months and the number of leap years between, etc. For the purpose of computing the orbits of planets, comets, double stars, and for many other purposes astronomers require such intervals frequently. To simplify the process Scaliger in 1582 introduced what he called Julian time, in which the days are numbered consecutively from 4713 B.C., the present Julian Year being 6638, and this day being Julian Day 2,424,419. If you want to know the number of days between, say, July 6, 1897, and today, you look up in the Nautical Almanac and find July 6, 1897, was Julian Day 2,414,112, so that the interval between is simply the difference of these numbers or 10,307 days, a simple and errorfree process. But the Julian Day began at noon, like the astronomical day before January 1; and as there was no decision in regard to it, controversy waxed fast and furious whether the Julian Day should also begin at midnight instead of noon. There were strong arguments on both sides, America generally in favour of the change and Europe opposed. Several organizations in the United States, without waiting for the Union, had made the change; and the joke is on them, as the Union decided unanimously, and I think rightly, to keep the Julian system continuous and unchanged from its hypothetical beginning of 4713 B.C.

If the Union had done nothing else than settle this controversial question, the assembly at Cambridge would have been well worth while.

Although, as you will have seen, the Union deals not so much with new as in deciding procedure arising from work already done, there was an evening meeting at which Professor Eddington, brought forward a very startling result in regard to the density of the stars, and I think you will find it interesting, as well as scarcely credible, to have the gist of his paper. We must remember that all the stars, including our sun, are entirely gaseous, vapours of metals and other elements, at very high temperatures, thousands

of degrees, and at different stages of density. You will remember that the diameter of Betelgeuse, the bright red star in Orion, was measured by the interferometer at Mt. Wilson some four years ago, and found to be about 300,000,000 miles. The average density of this distended body can hardly be greater than one thousandth part of the air we breathe or practically a vacuum, and yet it is a tremendous sun, thousands of times as bright as ours. Our sun is about a million times denser than Betelgeuse, and has a specific gravity about 1.4, water being the standard. Until recently we believed that stars could not be more dense than 4 or 5 times water, when they would perhaps liquefy, solidify, and cool down.

But about a year ago Eddington read a remarkable paper before the R.A.S. in which he showed that, owing to the very high temperatures in the interiors of the stars, from 3 to 20,000,000 degrees, the atoms of matter would have most of the outer rings of electrons knocked off, would hence be reduced in diameter about a hundredfold and could be packed together a million times more closely than ordinary atoms. In such a case ordinary limitations of density would be removed and an entirely gaseous star might be thousands of times as dense as water. This idea immediately served to explain a number of anomalous stars, such as the companion of Sirius, which have always been a great puzzle to astronomers. For owing to its revolution around Sirius we know its mass is 8/10 the sun, but it is some thousand times too faint for its mass and brightness. This theory of Eddington's removes the difficulty, because if its density increases sufficiently its diameter will shrink enough to make its computed and observed brightnesses agree.

But like all theories this one needed some observational evidence, and this was furnished by velocity observations of the star by Adams at Mt. Wilson two or three months ago. In this particular case he "killed two birds with one stone", proving the abnormal density and the third condition of relativity, the shift of the spectrum lines to the red in a heavy body, which in the sun amounts to about a hundredth of a wave length. The normal positions of the lines in the companion of Sirius were known from its known orbital motion around Sirius; and when Adams measured the

relativity shift it was found to be about a third of a wave length, thirty times as great as the sun. A simple calculation showed that this remarkable star had a diameter of only 12,000 miles, 50% greater than the earth, but that it was nearly 60,000 times as dense as water and 3,000 times denser than platinum. At the same time it is entirely gaseous, an almost inconceivable condition.

To make these figures more concrete, let us take a couple of examples. This glass which holds about eight ounces of water would contain about 3½ grains of ordinary air, but only 1/200th grain if filled with the matter from Betelgeuse. But if it were possible to have it filled with the seething torrid gas from the companion of Sirius it would weigh no less than 15 tons, and would go crashing through the table and floor and bury itself in the ground. Or if one of us could be transported to the surface of this star, and could escape complete vaporisation at its temperature of some 14,000 degrees, gravity would be so powerful that we would weigh over a thousand tons, and would be crushed flatter than would be possible by a 100 ton roller. These well-substantiated figures form one of the most startling achievements of modern science, and though it is quite impossible to imagine a glassful of gas weighing 15 tons, there seems to be no escape from the facts.

But besides the formal part of such meetings, there is another and in many respects, a more valuable one, the social side. There are unrivalled opportunities at such international gatherings of making and renewing friendships, and for informal discussions on points of mutual interest. Every scientist remarks, and generally with envy, that this feature is especially noteworthy at astronomical meetings, due partly to the geniality and friendliness of astronomers, but principally to the small number of professional astronomers, about one per million of the population, while the principal exponents scarcely exceed 200 in number.

Cambridge then, where some 200 of the most eminent astronomers were gathered together, the university of Newton, Adams, Clerk Maxwell, the breeding place of Astronomers Royal and First Assistants, was an ideal place for this meeting, and formed an inspiring atmosphere for both the business and social sides of the gathering. The latter side was well arranged, beginning with an afternoon reception at the Vice-Chancellor's, and continued

by a garden party at the two observatories, by evening receptions at St. John's, Sidney Sussex and Queen's, and by a luncheon at the Vice-Chancellor's.

The meeting at Cambridge was followed by three days of splendid functions in London. The 250th anniversary of the founding of the Royal Observatory was celebrated on July 23 by an inspection of its equipment and work by the King and Queen, the first royal visit in 250 years, and by a government luncheon at the Savoy Hotel on July 24. All the visiting astronomers were invited to the observatory for the celebration, but only eight were presented to their Majesties, the Astronomer Royal for Scotland, H. M. Astronomer at the Cape, ourselves, and the five chief officers of the Union. I need hardly tell you that to such loyal subjects as ourselves we considered it a very high honour. The ceremony took place in the Octagon Room, the most famous room in the observatory, and afterwards the Royal Visitors were shown the observatory by the Astronomer Royal and Lady Dyson. As the King was a naval officer and must have had some astronomical education, I venture to believe that he would not find this function so boring as many he has to and does attend with a cheerful and interested expression. Their Majesties stayed about two hours and had tea with their host and hostess in the Octagon Room, altogether a memorable occasion.

The Government Luncheon at the Savoy Hotel on July 24, also in connection with the Royal Observatory celebration, was given by the Admiralty, the department in charge, to all the delegates of the Union, and was presided over by the First Lord, Bridgman, the chief negotiator in the coal strike then impending, who had come direct from this meeting specially to the luncheon, (Mr. Bridgman's address was given in the August-September JOURNAL). In the three days after the Cambridge Meeting I also addressed the two British Astronomical Societies, the whole forming a strenuous but splendid twelve days.

In thus telling of the honours which English science accorded me, I can assure you that I considered them not as personal tributes, but as marks of appreciation of the work of our Observatory, in which I include my colleagues, and as symbols of the high standing of Canada in the scientific world. As such I rejoiced exceed-

ingly in them, and as you can imagine we had a very wonderful time.

I would like to take a moment to say a word about Canada in England. I think the reception accorded me shows our scientific status, while our exhibit at Wembley indicates graphically our agricultural and industrial capacity; and I am sure Canada and Canadian affairs are looming more largely than ever in England. I would also make special mention of Canada House, our headquarters in London. When I was in England twelve years ago the High Commissioner's Offices were in dingy quarters in out-of-the-way Victoria St. They were moved recently to somewhat better quarters on the first floor of Kinnaird House in Cockspur St. We had the good fortune to be in London when the new Canada House on Trafalgar Square was opened officially with a golden key by the King and Queen on June 29. It was a very pleasing and interesting ceremony for a Canadian to participate in, and it was very gratifying to us to see Canada at last represented in London by a building at once dignified, stately and impressive, and tastefully and beautifully furnished, situated on the best and most central site in the Empire. These offices form a splendid nucleus of Canadian influence and effort, a fitting symbol of our place in the Empire.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

The Deepest Hole in the Earth

In *Science* for October 23, Dr. Frederick P. Vickery states that on September 25 the Miley Oil Company's No. 6 well, located at Athens, Los Angeles County, California, became a producing well at a depth of 7,591 feet, thus breaking previous records. It is the deepest hole ever drilled, and is lined with iron pipe as follows: 15½-inch, cemented at 988 feet; 8¼-inch, cemented at 5,289 feet; 4¾-inch landed at 7,591 feet and cemented through perforations at 7,305 feet.

The well was drilled with rotary tools in 230 working days, an average of 33 feet per day. The total cost was $164,000 or $21.60 per foot. It produces 150 barrels per day with 20 per cent. of salt water. A gas lift is used to make the well flow as pumping was considered impracticable on account of the depth.

Early Life of Andrew Elvins

In the issue of *The Western Morning News and Mercury* for October 28, published at Plymouth and Exeter, England, is an article on Andrew Elvins, written by Mr. T. H. L. Hony, of Fowey, Cornwall. The information in it is obtained largely from the biography published in this Journal for March 1919. Mr. Elvins died on October 28, 1918, in his 96th year. Mr. Hony's sketch contains some details which only one living in the neighbourhood could obtain. These are contained in the early paragraphs, quoted herewith.

Andrew Elvins was born at Polgooth, St. Austell, May 4, 1823. His father, Richard Elvins, and his mother, formerly Mary Johns, and their forbears were Cornish people. Richard Elvins was a tin miner. The entries of the monthly payments to him are still to be seen in the mine books at Polgooth. The last entry was in January, 1861. Richard Elvins died in 1866, and was buried at St. Mewan, where his wife was also interred.

Both he and his wife were religious people of the Methodist stamp. They were both inclined to literature, and Richard Elvins published a book of poems of a religious tendency. A record of this publication is to be found in "Bibliotheca Cornubiensis".

Andrew's early opportunities for education were very limited. At the age of ten he left school and went into the mine with his father, his task being to separate the tin-bearing from the other rocks. After two years of this work he left and became an apprentice to James Drew, a tailor, in the neighbouring village of Sticker. During his apprenticeship he attended night school, and at this period he developed a taste for geology. He also discovered in a small lending library connected with the school Sir John Herschel's "Outlines of Astronomy". He used to make sketches of the constellations, not knowing their names, and on recognizing them afterwards with the aid of *Chambers's Encyclopedia*, he was greatly pleased.

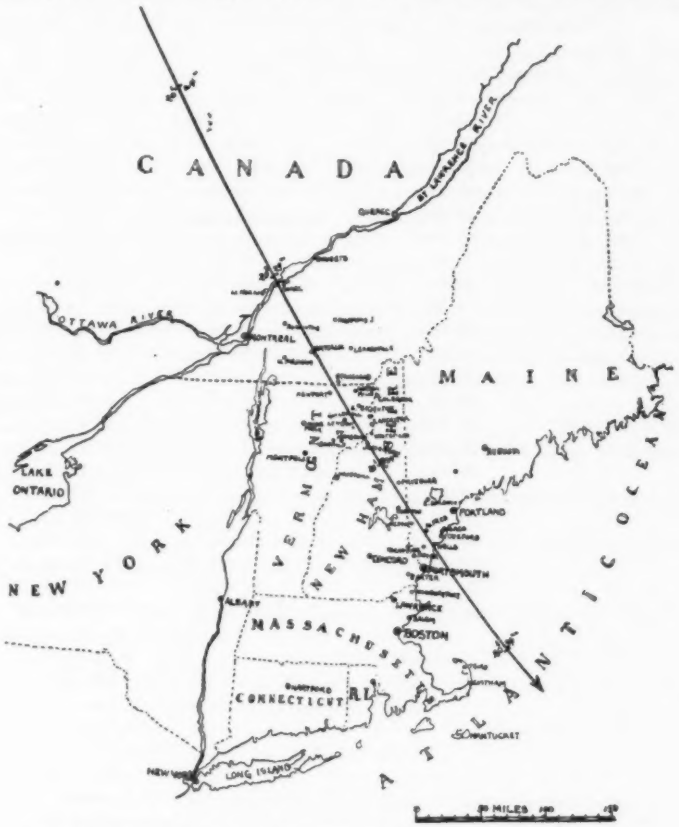
ANOTHER HONOUR FOR DIRECTOR PLASKETT

The recent Convocation of the University of British Columbia was the first to be held in the permanent buildings of the University on Point Grey, and in celebration of the occasion the honorary degree of LL.D. was conferred on seven persons. One of these was John S. Plaskett, director of the Dominion Astrophysical Observatory, Victoria, B.C. The President of the University made the following remarks in introducing him:

In ancient days it was a prerogative solely of demigods or of mortals otherwise favoured by divinity to have their names written on the sky; and that, only when they had ceased—usually by a merciful deliverance—from the business of living. Doubtless John Stanley Plaskett, Fellow of the Royal Society and Director of the Dominion Astrophysical Observatory, would not claim to belong to either of these classes, and unlike them he is certainly very much alive. But, with equal certainty, he has inherited and merited their heroic distinction, for the mysterious double star that he discovered now bears his name. It rather appals ordinary mortals to learn that this binary is the most ponderous and vast of the stellar systems. But there is some alleviation in the fact that the system is known familiarly as the "Plaskett Twins", and that they are the hottest entities known to man. Fortunately the name of their discoverer not only is placed aloft among the stars, but is known also as belonging to a power still vital and productive in the mundane sphere of science. This is a region that does not recognize any national boundaries, but Dr. Plaskett will not deny to Canada or to the University of Toronto the right of claiming him as their own. The University of his adopted province now proposes to share the lustre of his name.

THE TOTAL ECLIPSE OF AUGUST 31, 1932

From Oppolzer's *Canon der Finsternisse* the path of totality of this eclipse would be judged to pass along the east side of Hudson Bay and across the St. Lawrence River near Anticosti Island and then into the Gulf of St. Lawrence, not touching the maritime provinces of Canada or the eastern states. But a later computation by Mr. F. E. Seagrave, verified at the Goodsell Observatory,



The Central Line of the Total Eclipse of the Sun which occurs on August 31, 1932
(From *Popular Astronomy*, November, 1925)

places the path much farther west. According to it the centre line crosses the St. Lawrence at Sorel, at 3.29 p.m., then passes near Waterloo, Que., and across Vermont, New Hampshire and Maine.

The following table gives the co-ordinates of points on the central line and the time of total eclipse at these points; while the accompanying diagram shows the path across Quebec and the eastern states.

CO-ORDINATES OF POINTS ON CENTRE LINE OF TOTAL ECLIPSE

Greenwich Civil Time	Longitude W.	Latitude N.
h m	° ′	° ′
19 19	116 43	81 04
19 24	105 07	77 22
19 29	98 50	74 03
19 34	94 36	71 03
19 39	91 25	68 17
19 44	88 51	65 41
19 49	86 39	63 13
19 54	84 43	60 53
19 59	82 56	58 37
20 04	81 16	56 26
20 09	79 40	54 18
20 14	78 05	52 14
20 19	76 30	50 11
20 24	74 53	48 10
20 29	73 11	46 10
20 34	71 23	44 11
20 39	69 25	42 12
20 44	67 13	40 12
20 49	64 41	38 10
20 54	61 36	36 04
20 59	57 34	33 50
21 04	49 01	30 35

C.A.E,

MEETINGS OF THE SOCIETY

At Toronto

April 7, 1925.—The regular meeting of the Society was held at the Physics Building, Mr. A. F. Hunter in the chair.

Mr. Ralph E. Nelson of Unity, Sask., was elected to membership in the Society.

The speaker of the evening was Mr. A. F. Miller, his subject being "The Tricentenary of Cassini I". Giovanni Domenico Cassini was born in 1625 near Nice. His studies were varied, including, besides astronomy, Latin poetry, philosophy and theology. In 1649 he became professor of astronomy at the University of Bologna and while there rendered valuable services to Pope Alexander III as a hydraulic engineer. He made observations on the obliquity of the ecliptic and the horizontal parallax and apparent diameter of the sun. In 1667 he constructed a set of tables for finding longitude from observations of Jupiter's satellites. In 1669 Cassini moved to Paris and on the completion of the Paris observatory became Chief Astronomer of that institution. About this time he measured the period of the sun's rotation, discovered a new satellite to Saturn and noted the dark space separating its rings, estimating the parallax of the sun at not more than ten seconds, and offered an explanation of the zodiacal light which has not been greatly improved upon. He also established a school of astronomy at the observatory, from which trained observers were sent out all over the world.

Cassini became blind in 1711, and died in 1712 at the age of 87 years. His work was continued by his son, and for three generations the name of Cassini was prominent in French astronomical circles.

Dr. R. K. Young produced a slide which showed the type of telescope used in the days of Cassini.

Mr. G. M. Bryce made a few remarks on the observation of shadow bands at the recent eclipse, as reported in the March periodicals.

October 6.—The regular meeting of the Society was held in the Physics Building, Mr. A. F. Hunter in the chair.

The following were elected members of the Society:

Miss Martha Fitch, B.A., Moulton College, Toronto.
Herbert H. Hyde, North Battleford, Sask.
C. E. Gummer, M.A., Ph.D., Queen's University, Kingston.
J. T. Holliwell, 136 Cedric Ave., Toronto.
W. Cannon, 24 Mayfield Ave., Toronto.
Thomas L. MacDonald, M.A., B.Sc., F.R.A.S., Glasgow, Scotland.
Miss Margaret A. Knight, 129 Ulster St., Toronto.

The Assistant Librarian reported having received during the summer over two hundred periodicals from various parts of the world.

Mr. Hunter remarked that Venus and Jupiter were good objects for observation, the former reaching maximum brightness about the end of November. Brooks' Comet is also in good position for telescopic observation.

Dr. Chant remarked on the unusual opportunities for observing the aurora during the past month. He read a letter from Mr. W. E. W. Jackson describing the aurora seen at Edmonton on September 1. A letter was received also from Mr. Pearce of the Dominion Observatory at Victoria, B.C., describing a display on the 20th. Using magnetic charts for western Canada to get the declination and inclination at Victoria, Dr. Chant and Dr. Young worked out altitude and azimuth of the magnetic zenith, and found Mr. Pearce's estimate of the position of the centre of the corona to be within 2° of their result. Dr. Chant observed an aurora on the 14th, and on the 17th September, while crossing the Atlantic; and several members reported having seen displays on the 14th, 21st and 22nd.

In the absence of Mr. Hassard, who was to have given a report of observations during the summer, Mr. A. F. Miller described his observations on the sun, moon and some of the planets. Mr. Miller noticed sunspots at various times; the 8th to the 12th of July, the 26th to the 31st of August, and the end of September being periods of considerable activity.

Mr. Miller also observed the moon, and noted particularly a peculiar hollow or trough-like appearance of a ray situated slightly west of Tycho which could be seen even when the moon was nearly full. Observations were made on Venus and Jupiter and on some stars. From measurements extending over 25 years and using a measurement made by Webb in 1880, Mr. Miller calculated that the position angle of α Herculis has changed about 10½° in 45 years.

A question was asked as to the possible effect on the position of the pole by the diversion of the water from the great lakes through the Chicago canal. Dr. Chant replied that the mass of the water affected was small in comparison with the mass of the earth, and that the effect would therefore be very slight.

October 20.—The regular meeting of the Society was held in the Physics Building at 8 p.m., Mr. A. F. Hunter in the chair.

A press despatch reported the discovery of a comet near Theta Pegasi, but Mr. J. R. Collins and Mr. A. F. Miller were unable to find any trace of it.

At sunset on the 17th September while crossing the Atlantic, Dr. Chant observed the phenomenon known as the green flash. Rev. Dr. D. B. Marsh, lately of Bermuda, described conditions for observing in that country. The days and early evening are generally favourable for observation, but as no part of the Island is more than a mile distant from the ocean, vibrations from high seas and also from earthquakes make accurate and systematic observation difficult.

Mr. A. F. Miller reported considerable solar activity, there being five rapidly changing groups visible on the 17th October. He mentioned also that the variable Omicron Ceti is at present in good position for telescopic observation, though faint.

The speaker of the evening was Mr. J. R. Collins, his subject being "Recent Investigations, including the ether drift experiments". The first experiments to determine ether drift were performed by Michelson and Morley in 1887 at Cleveland. Within the last few years Prof. Miller has carried out similar experiments at Cleveland and at Mt. Wilson. He found a drift of 2 kilometres per sec. at Cleveland, 3 on the hills near by and 9 or 10 at Mt. Wilson, or an increase of drift with an increase in elevation. This result is antagonistic to Einstein's specialized theory of relativity. Mr. Collins read an article written by Prof. Eddington, in which he asserts that ether drift is disproved by the fact that measurements of right ascension and declination are applicable the world over.

Mr. Collins also described the use of the interferometer to find star diameters, the aperture of the telescope being widened by means of mirrors placed at some distance on each side. Such an instrument is now in process of construction with the mirrors 50 feet apart.

Mr. Wm. Gore made some remarks on the theory of the ether and its elastic properties, and by means of slides gave diagrams showing the strain in the lines of force in space due to a body at rest and in motion.

November 3.—The regular meeting of the Society was held in the Physics Building at 8 p.m., Mr. A. F. Hunter, Vice-President, in the chair.

The Librarian stated that recently many requests had been received for the publications of the Society, not only from our own country but also from China, Equador, Europe and other foreign countries. It is very desirable to exchange publications with the bodies desiring it, but the Society was somewhat embarrassed through a reduction in its income caused by the withdrawal of the annual grant from the Ontario Legislature, which the Society had received from its inception more than thirty years ago. The matter was left for action by the Council of the Society.

Elmer A. Smith, Hoboken, N.J., was elected a member.

The Assistant Librarian reported that 69 publications from various parts of the world and catalogues of stars from Yale Observatory, and the Ratcliffe Observatory, England, had been received.

Mr. Miller remarked that the face of the sun now visible presents very little evidence of activity.

Rev. Dr. D. B. Marsh then addressed the meeting, his subject being "The Bermuda Solar Eclipse Expedition to New Haven, Conn." By means of a series of slides, Dr. Marsh described Bermuda, its varied races of people, its hundreds of islands, its beautiful sunsets and many other interesting features. While in Bermuda Dr. Marsh made the time observations for the Islands and gave out the correct time to ships.

The eclipse expedition from Bermuda consisted of a party of five under the direction of Dr. Marsh. Three telescopes were set up at New Haven, Conn., the lenses having diameters 9 in., 4 in. and 3 in. respectively, while by means of amplifying lenses the equivalent focal lengths of the cameras were 22½, 10½ and 4½ ft. Four exposures of from 2 to 16 seconds were made with each camera,

the results being satisfactory, except that there was considerable halation in the plates. Dr. Marsh explained how the exposures were made and showed pictures of the observers, their apparatus and the results obtained. Bailey's beads were observed, but no observations of shadow bands were made.

Miss E. M. Budd mentioned several interesting items from the October magazines. An article in the *Journal of the Astronomical Society of South Africa* describes the discovery of Nova Pictoris by Mr. R. Watson. This star was about magnitude 2.3 at discovery, and later rose to magnitude 1.6. Another article in *English Mechanic* gave some useful hints on how to choose a telescope. Dr. Chant mentioned that another description of Nova Pictoris by Prof. Russell appeared in the *Scientific American* for October.

G. M. BRYCE,
Rec.-Secretary.

At London

The regular February meeting was held in the Public Library, London, Dr. H. R. Kingston presiding. Mr. Wm. Berney, 609 Oxford St., and Miss G. Menhennick, 89 Elmwood Ave., were made members of the Society. Dr. Kingston gave a ten-minute talk on the Late Winter and Early Spring Skies. The principal star groups were shown on lantern slides, and points of special interest regarding them pointed out.

Dr. E. T. White then gave a paper on the Calendar. The different kinds of time, such as solar time, sidereal time, local time were described, also an account of the introduction of standard time. A short account was given of the reform of the calendar by Julius Caesar, and also the second great reform when the Gregorian Calendar was introduced in 1582, to correct the defects of the Julian Calendar. The Julian year being about eleven minutes too long, the vernal equinox had receded to the 10th of March. Ten days were ordered dropped after October 4, 1582. The Gregorian Calendar gradually replaced the Julian Calendar, although even to-day the Julian Calendar is in use to a limited extent. The proposed reforms were next discussed, and Dr. White pointed out that to-day there is a movement for a simplification of the calendar.

The following proposed calendars were examined: Grosclaude's fixed calendar, which gives a perpetual calendar with but few changes from the present calendar. Some of its merits are (*a*) all months have 26 working days, (*b*) all quarters are of equal length, (*c*) each quarter begins on a Monday and ends on a Sunday. Next we have Dalziel's Calendar, with two months of 28 days each, and one of 35 days in each quarter. Then again there is the thirteen-months calendar, with 28 days in each month. All these calendars introduce a non-week day each year, and an extra non-week day each leap year. They also provide for a fixed Easter.

It was pointed out that the agitation for a fixed calendar is still in progress. The International Chamber of Commerce has the matter under consideration, and the League of Nations has appointed a special committee to review the subject and make recommendations. Emphasis was placed on the need for

spreading information on the subject, so that all classes liable to be affected by the proposed changes may have an opportunity to study them and give their views on the matter.

March 13.—The regular meeting was held at 8 p.m. Miss C. M. Jeffery, 42 Hayman Court, was made a member of the Society.

Mr. T. C. Benson spoke on the Refracting Telescope. Mr. Benson pointed out that the essential parts of a telescope are the object-glass and the eye-piece. The object-glass brings the rays of light which come from a distant object to a focus, and increases the brightness of the image which is formed. The brightness of the image does not depend upon the focal length of the lens but on its area. Therefore it varies as the square of the diameter of the lens. The eye-piece is used to magnify the image so that the details can be seen more clearly. Mr. Benson next by means of diagrams dealt with the laws of refraction. He pointed out that when light passes through a single lens the rays of different colours are differently refracted. This tends to produce a coloured image. This "chromatic aberration," as it is called, is corrected by using a lens made of two different kinds of glass. The equatorial and the altazimuth mountings were then described. Diagrams and lantern slides were used to add clearness to the lecture.

April.—Especial interest attached to the April meeting because of the visit of Sir Frederic Stupart, who spoke on "Facts, Fancies and Fallacies regarding the Weather". Sir Frederic pointed out that the weather is of interest to everybody. Nevertheless we are accustomed to take the weather as it comes, and do not ask questions unless something unusual occurs. Recently the disastrous tornado has called out many questions as to the causes of tornados, and why they occur more frequently in some places than in others. The principal influences affecting climate were given as follows: latitude, altitude, geographical position, circulation of the atmosphere, and the output of solar energy. The most important factor in determining weather is atmospheric circulation. Trade winds are caused by the differences in barometric pressure at the equator and further north or south. Near the equator there is a belt of low pressure, and north or south of the equator the pressure gradually increases in amount till we reach a ridge of high pressure. The air tends to flow from the region of excess to the region of deficiency. North of the ridge the general flow is towards the east. The situation is made more complex by the fact that the hemispheres are partly land and partly water. The land absorbs heat during the day and parts with it at night. The oceans absorb heat less readily and part with it less readily than does the land.

Cyclonic areas are those regions on the earth's surface where the atmosphere is blowing spirally inwards towards a common centre. An eddy is formed in the general flow of the atmosphere. In the middle latitudes the general drift is towards the east.

Sir Frederic used a series of weather maps to show how these cyclonic areas change from day to day. He pointed out that the movement of an eddy in the

atmosphere is uncertain, and that this makes forecasting difficult. No long distance forecasting is made except by those who know very little concerning the influences which affect the weather.

After Sir Frederic finished his address a spirited discussion took place, many questions were asked and answered.

E. T. WHITE,
Secretary.

At Montreal

November 10, 1925.—The meeting was held in Macdonald Physics Building, the President, Mr. Justice E. E. Howard, in the chair.

The lecturer for the evening was Mr. Leon Campbell, Harvard College Observatory, who gave an illustrated address on Variable Stars and the organization and achievements of the American Association of Variable Star Observers.

Methods of detecting variables were described, and the classification of variables was outlined: irregular, long period almost regular, absolutely regular Cepheid variables, and eclipsing binaries. Light curves compiled from many thousand observations on over 400 variable stars display characteristics which lead to a grouping into seven distinct types of regular variation, besides the very erratic curves of the irregular stars like R Coronae, SU Tauri, SS Aurigae.

The Cepheid law was touched upon and its value in connection with the determination of the distances of star clusters.

Novae and the changes in their spectra were briefly discussed. The polarizing photometer was described, and its value indicated as a means of making more precise estimates of relative brightness than is possible with the unaided eye.

After considerable discussion centering around the well-known stars Algol and Mira Ceti, a hearty vote of thanks was tendered the speaker.

After the public meeting the annual meeting of the Society was held. Reports for the 1924-25 season were given by the Treasurer and by the Secretary, after which the election of officers took place, resulting as follows:

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	A. H. S. Gillson	E. E. Howard
	H. W. Jesmer	G. Sample

After the new president had taken the chair the meeting adjourned.

A. V. DOUGLAS,
Secretary.

The Royal Astronomical Society of Canada

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